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LONGWALL SUPPORT CONTROL FOR CONTROLLING THE MOVEMENTS OF LONGWALL SUPPORT UNITS IN THE LONGWALL OF A MINE

BACKGROUND

The invention relates to a longwall support control for controlling the movements of longwall support units in the longwall of a mine.

A control system of this type is disclosed, for example, in DE 102 07 698.7 A1 as well as in DE 199 82 113.5-24 A1 (US 6,481,802).

This longwall support control permits activating the individual longwall support control units, in the present application also referred to as mining shields, from a central control or by individual control units, which are each associated to a mining shield (mining shield control devices). In this connection, it is possible to activate from one of the mining shield control devices respectively the adjacent or a plurality of adjacent mining shields. Basically, the control signals are supplied to all mining shield control devices via a common line. However, the mining shield control devices are programmed such that only that mining shield control device is addressed and caused to execute the switching commands, to which the code word is associated that is transmitted along with the control command. All other mining shield control devices retransmit the control signal with the code word.

With an input of a control command, the common line (bus line) is taken.

It is an object of the invention to improve a longwall support control, which permits transmitting

along with a control signal also other signals at the same time.

BRIEF SUMMARY OF THE PRESENT INVENTION

The present invention achieves the above and other objects by providing a longwall support control for controlling the movements of longwall support units in the longwall of a mine, comprising a central control system; and a plurality of control units, of which a separate mining shield control device is locally and operationally associated to each longwall support unit, the mining shield control devices connecting to the central control system and to one another by means of at least one bus line, through which each of the mining shield control devices can be called up from the central control system or an adjacent mining shield control device for inputting a control command, and with each mining shield control device being programmed such that it is possible to deliver for execution to the mining shield control device, control commands that are received via the bus line, and which each store a code word associated with the respectively called up mining shield control device, wherein the mining shield control devices connect via a parallel bus line to the central control system and to one another, and the mining shield control devices are programmed such that signals that are received via one of the bus lines, and which do not store a code word associated with the respectively called up mining shield control device, are retransmitted to the adjacent mining shield control device.

Because of the length of the longwall, there is a risk that the signals from mining shield control device to mining shield control device are so greatly attenuated that they can no longer be received by far removed mining

shield control devices, in particular by the central control system.

This problem is avoided for both bus lines and all transmitted signals respectively by including in the mining shield control device, an amplifier for the signals that do not store a code word assigned to the respectively called up mining shield control device, and which come in via at least one of the two bus lines.

Irrespective of the input of control signals, the invention makes it also possible to transmit measuring signals or other signals of state to the operator or the central control system. Likewise, in the case of each control signal, it is also possible to release at the same time and without a time delay an acknowledgment signal, which acknowledges the receipt and/or the execution of the control command.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference will now be made to the accompanying drawings, wherein:

Figure 1 is a sectional view of a longwall face with a longwall support;

Figure 2 is a schematic view of a coal cutting machine and a group of longwall supports; and

Figure 3 illustrates a schematic arrangement of a central control system and mining shield control devices.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 illustrates one of longwall support units **1-18**. Figure 2 illustrates a plurality of longwall support units **1-18**. The support units are arranged along a coal bed **20**. The coal bed **20** is mined in a working direction **22** with a cutting device **23, 24** of an

extraction machine **21**. In the illustrated embodiment, the extraction machine is a coal cutting machine **21**.

The coal cutting machine **21** is movable in a cutting direction **19** by means of a cable not shown. It possesses two cutting rolls **23**, **24** that are adjusted to different heights, and shear the coal face. The dislodged coal is loaded by the coal cutting machine, also named "cutter-loader," on a conveyor. The conveyor consists of a channel **25**, in which an armored chain conveyor is moved along the coal face. The coal cutting machine **21** is adapted for moving along the coal face. The channel **25** is subdivided into individual units, which are interconnected, but are capable of performing a movement relative to one another in the working direction **22**. Each of the units connects to one of the longwall support units **1-18** by means of a cylinder-piston unit (advance piston) **29**, which is used as a biasing means. Each of the longwall support units serves the purpose of supporting the longwall. To this end, a further cylinder-piston unit **30** is used, which stays a base plate relative to a roof plate. At its front end facing the coal bed, the roof plate mounts a so-called coal face catcher **48**. This catcher is a flap that can be lowered in front of the mined coal face. The coal face catcher must be raised ahead of the approaching coal cutting machine **21**. Likewise to this end, a further cylinder-piston unit not shown is used. These operating elements of the individual longwall support are shown only by way of example. While additional operating elements are present, they need not be mentioned and described for the understanding of the invention.

As aforesaid, each of the biasing means is a hydraulic cylinder-piston unit.

These cylinder-piston units are actuated via valves **44** and pilot valves **45**. The pilot valve mounts a valve control device **40**, i.e., a housing that accommodates the valve control.

In Figure 2, the coal cutting machine moves to the right. For this reason, it is necessary that the coal face catcher of the longwall support unit **17** be folded back. On the other hand, the unit of channel **25** on the longwall support unit **9**, which is located - in the direction of movement **19** -- behind the coal cutting machine **21**, is advanced in the direction toward the mined coal face. Likewise, the following longwall support units **8**, **7**, **6**, **5**, and **4** are in the process of advancing in the direction toward the longwall or the mined coal face. The coal face catcher on these longwall support units has already been lowered again. The support units **3**, **2**, **1** have finished their approach and remain in this position, until the coal cutting machine approaches again from the right.

As a function of the movements and the instantaneous position of the coal cutting machine, the control of these movements occurs in part automatically, in part by hand. To this end, a separate mining shield control device **34** is associated to each of the longwall support units **1-18**, and longwall control devices **33** are separately associated with respective groups of longwall supports or mining shield control devices. Each of the mining shield control devices **34** is associated to one of the longwall support units **1-18** and separately connected to the pilot valves **45** and main valves **44** of all biasing means of the longwall support units **1-18** via a valve control device (microprocessor) **40**.

Each of the mining shield control devices serves as a central longwall support control. However, a group of

a plurality of mining shield control devices can be superposed by a longwall control device **33**, or also the entirety of the mining shield control devices can be superposed by a central longwall support control system (primary central control system **50** and/or secondary central control system **51**), which connects to the mining shield control devices. Such an arrangement is shown in Figure 2.

The central longwall support control system consists of the primary central control system **50** and secondary central control system **51**.

A cable **58** (bus line) interconnects all mining shield control devices **34**. Each of the mining shield control devices retransmits the operating commands. The operating command triggers in a certain mining shield a certain operating function, for example, in the sense of robbing, advancing, and setting. This mining shield operating command is received and retransmitted by all mining shield control devices **34** via the bus line **58**. All operating commands of one of the longwall control devices are directly transmitted to the mining shield control device that is directly connected to the longwall control device **33**. From this mining shield control device, the operating commands then reach all other mining shield control devices **34** via the bus line **58**. However, by a predetermined coding, only one of the longwall support units **1-18** or a group thereof is activated for carrying out the respective shield functions. The activated mining shield control device then converts the received operating command into valve control commands to the control valves or main valves that are associated to the particular mining shields.

The automatic release of the functions and operating sequences is disclosed, for example, in DE-A1 195 46 427.3.

For a central manual operation of the command input, use is made of a control device **37**, which is designed and constructed for manual operation and carried along by the operator. To input the command, the operator can be outside of the longwall, or stand at least at a distance from the instant working location.

The hand-operated device connects by means of radio to radio receivers **38** of the longwall control devices **33**. The hand-operated device may have the shape of a rectangular block and comprises operating keys on its one side (control side). With these keys, it is possible to input also the code of each longwall support control (one of the mining shield control devices **34.1, 34.2...**) that is to be operated, and an operating command to release a desired function or a desired operational sequence (for example, robbing or advancing). For a radio transmission, for example, an antenna **39** of the hand-operated device is used.

When the operator rotates the hand-operated device about its longitudinal axis by 180°, he will see the control side of the device. This side comprises two diodes, a display, as well as additional keys. With his head lamp, the operator is able to illuminate the two diodes. Only when he covers in this process the one of the diodes, for example, with a finger, will the checking function of the hand-operated device be started. For an inspection, the operator inputs the code of the longwall support that is to be inspected. As a result, the hand-operated device connects via an infrared transmitter/receiver **35** to a tuned infrared transmitter/receiver **36** on the longwall control device **33**

that is addressed by the code. By means of one of the keys, it is now possible to recall certain functions or operating conditions. To this end, the longwall control system stores a program, which permits directing a sequence of inquiries concerning functions, operating conditions, and operating functions of a certain mining shield (longwall support unit) to the mining shield control device that is addressed by codes, and performing same thereon. Subsequently, the received data are transmitted by means of the infrared transmitters/receivers **35**, **36** to the hand-operated device, and shown on the display. In this manner, the operator is able to convince himself, whether a certain longwall support unit is still fully operable, or whether it requires maintenance or replacement of operating elements or control elements.

This enables a reliable, trouble-free, and robust operation of the coal cutting machine and the longwall support, which requires little operating expenditure. It has been found that even in underground mining, a reliable, trouble-free radio transmission of the required position and direction signals is possible, and that even in the case of a significant longwall length, the longwall support control system can be reliably controlled via one or few radio receivers. To this end, the control device has the characteristic of retransmitting signals that are transmitted to one or individual control devices, to the others, and of enabling, via a common computer capacity, a reliable investigation of the longwall support units that are to be addressed respectively.

As aforesaid, the mining shield control devices **34** are interconnected by means of the cable **58**, which has in the designs of the art only two conductors, and serves

for serially transmitting respectively a code word and the mining shield operating command. Only that mining shield control device **34** (longwall support units) is addressed, whose stored code word is identical with the transmitted code word. Thus, the cable **58** is a two-conductor cable, which extends in the form of a bus line from one mining shield control device **34** to the next, and also interconnects the primary central control system **50** and the secondary central control system **51** via the intermediate mining shield control devices **34**.

The present invention uses in the place of the previous single two-conductor cable **58**, parallel thereto a second two-conductor cable **59**, in the present application, also named parallel bus. In the present application, the cables **58, 59** are also called bus lines.

The wiring principle of the cables in the individual mining shield control devices **34** is shown in Figure 3. Illustrated are two mining shield control devices **34.1** and **34.2** of a plurality of mining shield control devices. The mining shield control devices connect via the bus lines **58** and **59** to the primary central control system **50** and secondary central control system **51**. The bus line **58** has two phase conductors **58.1** and **58.2**; the bus line **59** has two phase conductors **59.1** and **59.2**.

All four phase conductors of the two bus lines connect to input elements **52** of the mining shield control devices **34.1, 34.2....** From the input elements, the incoming signals are processed in the mining shield control devices, i.e., they are first checked to the extent whether the transmitted code word corresponds to the stored code word associated to this particular mining shield control device. Provided the signals being transmitted are control signals, they are then processed and retransmitted to the corresponding operational

elements of the shield, which have been previously described.

Each of the phase conductors **58.2** and **59.2** of each of the bus lines is then supplied to a switching element **53**. The corresponding phase conductors leave the switching element **53** via its output and subsequently enter the corresponding switching element **53** of the adjacent mining shield control device **34.2**. In the switching element **53**, the two phase conductors **58.2** and **59.2** can be separated synchronously or individually.

The other phase conductors **58.1** and **59.1** of the bus lines **58** and **59** are then supplied to an amplification element **54**. From the output of the amplification element, the corresponding phase conductors are each supplied to the amplification element of the adjacent mining shield control device **34.2**... Each mining shield control device **34.1, 34.2...** has a further "right-hand" input element **52**, which receives and processes the signals that come in from the right side, i.e., the secondary central control system **51**, or a mining shield control device **34.3...** located further to the right. Adjacent mining shield control devices **34.1**, **34.2** are thus again connected by two cables, which each have two phase conductors.

The switch **53** with its two switching elements is normally closed, so as to allow signals to pass through it. However, a separation of the bus lines will proceed upon occurrence of failures. This will facilitate trouble shooting on the one hand. To this end, one of the control devices (primary and secondary central control systems, hand-operated device, longwall control device, or mining shield control device) will open the switching elements of the mining shield control devices on the right or left, individually and serially.

Thereafter, a control signal will be input. Since the addressed mining shield control devices immediately acknowledge the control signal, it will then be possible to determine, which of the mining shield control devices are located beyond the faulty mining shield control device. On the other hand, the separation can proceed in the case of failure for purposes of isolating a faulty mining shield control device and separate it from the bus line or lines. As a result, the remaining mining shield control devices will remain activatable, and the failure can be eliminated without shutting down the longwall.

In the amplification element **54**, the incoming digital signals are refreshed. This occurs by determining in the amplification element, whether the incoming signals exceed a certain predetermined threshold value. If this is the case, signals of greater strength, preferably of the original strength, will be generated in the output, so that transmission of the signals through all mining shield control devices is ensured. This type of amplification presents itself in particular, since control signals, measuring signals, etc. are transmitted in digital form.

When one of the central control systems **50, 51**, or the hand-operated device **37** (Figure 2) inputs a control command into the system, the control command will be transmitted via the respectively free bus line **58** or **59**. In this process, the control commands are transmitted in the described manner through the individual mining shield control devices **34.1, 34.2...** Only that mining shield control device will be addressed, whose stored code word corresponds to the code word that is assigned to the control signal. The receipt and/or the execution of the corresponding control command can be acknowledged by a feedback signal, since one of the two bus lines **58** or **59**

is available for this purpose. The feedback can occur immediately and without time delay, so that also an immediate control is possible on the input device, i.e., primary central control system **50**, secondary central control system **51**, or hand-operated device **37**. The corresponding control signals are retransmitted to the valve control device **40** (Figure 1), whereby the control magnet **47** of the pilot valve **45** is activated, and the respective main valve **44** of the biasing means **30** is actuated. It is now also possible to retransmit, via the bus lines, the signals of the pressure sensors, which are arranged for controlling and monitoring on each of the biasing means and/or valves.

Many modifications and other embodiments of the invention set forth herein will come to mind to one skilled in the art to which this invention pertains having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.